APPLARATUS FOR SUPPORTING FLOATING LOAD
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This invention relates to apparatus for drilling in under-
water formations.

Although the apparatus of this invention may be used in drilling underwater formations for a variety of pur-
poses, it is particularly well suited for offshore oil explo-
ration, and it is described in detail with respect to that ac-

tivity.

At the present time, the oil industry is actively conduct-
ing offshore exploration by drilling from floating vessels
with equipment such as that described in U.S. Patent
2,808,229.

In a typical floating drilling vessel, a drilling derrick is
mounted on a mast over a central opening or well in the
vessel and drilling operations are conducted through the
opening. Due to wave action on the floating vessel when
in the open ocean, large deforming shock forces are im-
poved on the hull of the vessel. If these forces are un-
compensated, they are fully transmitted from the vessel
hull to the derrick truss and derrick proper, with the re-
sult that repeated strains are imposed which produce
fatigue of the structural members of the derrick and the
truss.

One solution to the problem is to build the vessel,
derrick and truss of such strength and rigidity that the
forces are overcome. However, such a solution would
greatly increase the size and cost of the floating drilling
equipment.

This invention provides a derrick truss or mounting in
which the deformations imparted by wave action to the
hull are prevented from being fully transmitted to the
derrick and its truss, thus permitting the use of more
lightweight and inexpensive construction than would oth-
erwise be possible.

In the presently preferred form of the invention, a der-
rick is disposed on an anchored structure or truss which in
turn is supported on the vessel. One end of the truss in-
cludes a footing rigidly attached to the vessel. The other
end of the truss includes a movable footing disposed to
move with respect to the vessel. Thus, as the vessel is sub-
jected to deforming forces by wave action, the movable
footing of the truss moves with respect to the vessel to
avoid the transmission of hull deformations to the truss
and derrick proper.

In the preferred form of the invention, the movable
footing of the truss is slidable and has means for prevent-
ing it from moving in a direction transverse to that in
which it is adapted to slide. A longitudinal tying mem-
ber is connected to opposite ends of the lower ends of the
truss for additional strength. Also in the preferred form
of the invention, each of the footings are pivotally con-
nected to the truss.

These and other aspects of the invention will be more
fully understood from the following detailed description
taken in conjunction with the accompanying drawings in
which:

FIG. 1 is a fragmentary side elevation of a floating
vessel on which a drilling derrick is mounted in accord-
ce with the invention;

FIG. 2 is a view taken on line 2—2 of FIG. 1;

FIG. 3 is an enlarged view taken on line 3—3 of FIG. 2;

FIG. 4 is a view taken on line 4—4 of FIG. 3;

FIG. 5 is an enlarged view taken on line 5—5 of FIG.
1; and

FIG. 6 is a view taken on line 6—6 of FIG. 2.

Referring to FIG. 1, a floating drilling vessel or barge
10 is anchored by a plurality of anchor lines 12 in a body
of water 14 over an underwater formation 15 in which an
underwater well 16 is being drilled from the floating ves-

sels. A rotary drilling derrick 18 which includes the usual

crane table 20, drill string 21 and other associated equip-
ment, which is not shown because it may be conventional,
is mounted on a derrick support or truss 22 which in turn
is mounted on the main deck 23 of the floating vessel.

As can be seen most clearly from FIGS. 1 and 2, the
derrick truss includes a pair of laterally spaced, longitudi-

nal and parallel arches 24 mounted on opposite sides of
a central opening or well 25 in the floating vessel. For
the purpose of reference, the right-hand ends of FIGS. 1
and 2 are considered the forward end of the vessel, thus
making the lower arched structure in FIG. 2 the starboard
arched structure. The port arched structure is identical
with that of the starboard arch, and therefore for brevity,
only the latter is described in detail below.

The starboard arch includes a longitudinal and horizon-


tal main brace or upper chord 26 welded at its forward
end to a downwardly and forwardly extending starboard
forward leg 28. A downwardly and rearwardly extending
starboard aft leg 30 is welded at its aft end of the starboard
main brace. Preferably, both legs and main brace of the
starboard arched structure are heavy I-beams with their webs lying in a common vertical plane. A star-

board aft footing 32 (see FIGS. 1 and 3) is attached to

the lower portion of the starboard aft leg and rests on the
main deck so that it is slightly fore and aft longitudinally
but not laterally. The footing for the starboard aft leg is iden-
tical with the footing for the port aft leg and similar to
that of the footings for the port and starboard forward
legs of the truss, and therefore, only port aft footing is
described in detail.

The differences in structure between the forward and aft footings are pointed out below.

Referring to FIG. 3, the port aft footing includes a pair of
vertical gusset plates 34 welded to opposite sides of
the flanges of the lower end of the port aft leg, which is
cut off at a slight angle shown most clearly by the dotted
lines in FIG. 3. Going counterclockwise (as viewed in
FIG. 3), each gusset plate has a horizontal top edge 34A,
a forwardly and downwardly extending diagonal edge
34B, a relatively short vertical forward edge 34C, a
downwardly and rearwardly sloping lower edges 34D, a
convex trailing edge 34E, and a vertical rear edge 34F.
A separate transverse stiffener plate 35 is welded between
each gusset plate and the center of the web of the port
aft leg. Each stiffener plate is parallel to the flanges of
the leg and perpendicular to the web and gussets, and ex-
tends from the lower end of the web to the diagonal
gusset plates. A relatively large transverse and hori-
zontal pin 36 is disposed at its opposite end in a sepa-
rate bore 37 in each gusset plate and is welded to the rear
edges of the stiffener plates of the port aft leg and rests
in a semi-cylindrical cradle 38 formed in the upper hori-
zontal surface of a block 40 welded to the upper surface
of a slidable pad 42 which rests on a lubricated horizontal
plate 43 mounted on the main deck. The upper surface
of the lubricated plate provides a surface of low coefficient of friction so that the pad can slide freely longitudinally.
The lubricated plate can be of any suitable material such as a porous bronze plate impregnated with graphite and sold
by the Merrimack Brothers, Inc. under the trade name "Lu-
bride." This type plate was used and had a maximum
coefficient of friction of 0.1 at 1,000 pounds per square
inch, and a minimum tensile strength of 40,000 pounds
per square inch. A downwardly projecting external shear
leg 44 on the large pin extends down into a semi-annular
slot 46 formed in the center of the cradle so the pin and
leg are prevented from moving laterally with respect to
the block. The lower edge of each gusset plate is disposed between a respective pair of laterally spaced vertical side plates 48 welded to opposite sides of the top of the pad. The outer side plates are higher than the two inner side plates, and the two inner plates are also welded to the ends of the block. In addition, a pair of longitudinal reinforcing plates 59 are welded to the center of the forward and rear ends of the block and to the upper surface of the pad.

A longer and smaller pin 52 makes a slip fit through a longitudinal bore 54 in the larger pin and at each end projects through a respective hole 56 in each of the outer side plates 48. The ends of the smaller pin are of reduced diameter and externally threaded so a separate nut 58 threaded thereon outside each of the outer side plates holds the pin in the footing. Thus, the slidable footing is free to pivot with respect to the port aft leg about the longitudinal axes of the pins in a vertical longitudinal plane. The hull is reinforced underneath the footing below the main deck and includes a pair of vertically spaced horizontal upper and lower foundation plates 62, 63, respectively. A horizontal cover plate 64 is welded across the top edges of the gussets and an aft pair of laterally spaced long bolts 66 extend down opposite sides of the web in the leg through the spaced holes 67, 68, 69, 70, 71, 72 of the cover plate, top flange of the leg, slidable pad, lubricated plate, and upper and lower foundation plates, respectively. The aft pair of bolts make a loose fit in the cover plate bores, and the bolts in the top flange of the leg and the slidable pad are elongated in a longitudinal direction to accommodate the relative movement of the vessel deck as described below. A forward pair of laterally spaced long bolts extend down opposite sides of the leg web through a loose fitting bore 73 in the cover plate, a longitudinal slot 74 in the upper flange of the port aft leg, through a longitudinal slot 76 in each of the transverse stiffener plates 35, through a longitudinal slot 77 in the pad, and close fitting bores 78, 79, and 80 in the lubricated plate and upper and lower foundation plates, respectively.

As can be seen most clearly in FIG. 3, the bolts make a relatively close fit through the holes in the lubricated and foundation plates so that the bolts are substantially immobile with respect to the deck and hull of the vessel. However, the bores permit the bolts, deck, and lubricated pad to move longitudinally with respect to the footing. The bolts are held in place by nuts 80 at each end of the longitudinal vertical plane about the transverse pins in each of their individual footings.

A starboard longitudinal arch-tying member or lower chord 84 is bolted at its forward end between the rear portions of the gusset plates of the starboard forward leg, and bolted at its rear end between the inside forward portions of the gussets for the starboard aft leg footing. Preferably, the longitudinal tying member is made up of three collinear I-beams tied together by two splices 86. As shown in FIG. 1, the flanges of the I-beams are vertical. Referring to FIG. 5, adjacent ends of the I-beams of the tying member are splice welded by a pair of side plates 89 attached by bolts 90 to the flanges at the abutting ends of the individual I-beam sections, and upper and lower plates 92 are attached by bolts 94 to the webs at the abutting ends of the I-beam sections by bolts 94. The web of the central portion of the tying member rests on a pair of longitudinally spaced supports 96 mounted on the main deck. Preferably, the longitudinal arching tying member is assembled after the mounting of the respective footings on the deck, and the plates at the left-hand end of the left-hand splice are not bored and bolted until the setting of the footings is completed. The seats of the legs of the port arched structure are similarly tied together by a port longitudinal arch-tying member 97.

A horizontal forward lateral brace 98 is bolted at its ends to the forward ends of the horizontal main braces of each of the two arched structures. A horizontal aft lateral brace 100 is bolted at its opposite ends to the aft ends of the horizontal main braces of each of the two arch supports. An upwardly and rearwardly extending starboard forward diagonal brace 101 is bolted at its lower end to the lower portion of the starboard forward leg and is bolted at its upper end to a brace 102 bolted at the center of the forward lateral brace. An upwardly and rearwardly extending starboard forward stiffener brace 104 is bolted at its forward end to the central portion of the starboard forward diagonal brace and is bolted at its rear end to the starboard end of the forward lateral brace. The port forward leg is similarly provided with a port forward diagonal brace 106 and a port forward stiffener brace 108. The starboard aft leg has a similarly mounted starboard aft diagonal brace 110 bolted at its lower end to the leg and bolted at its upper end to a brace 112 bolted to the center of the aft lateral brace. The lower end of a starboard aft stiffener brace 114 is bolted to the central portion of the starboard aft diagonal brace and the upper end of the stiffener brace 114 is bolted to the starboard end of the aft lateral brace. The diagonal braces just described are I-beams with their webs disposed in vertical planes, and the respective stiffener braces are T-beams.

A port aft diagonal brace 116 is bolted at its lower end to the port aft leg and at its upper end to the aft bracket on the aft lateral brace. The port aft diagonal brace is also an I-beam with its web in a vertical plane, but instead of a stiffener brace, it has a pair of T-beams 118 welded to the opposite sides of the center of its web as shown in FIGS. 2 and 6.

In the operation of the equipment shown in the drawings, the vessel is subjected to a considerable load in its central portion due to the heavy drill string carried by the derrick. As waves act on the vessel to exert a movement which tends to deform the upper surface of the main deck, the movement of the deck is not transmitted to the truss or derrick, because the deck under the slidable footings moves with respect to the footing. In addition, the angle of the deck with respect to the truss beams is such as to cause the footings to pivot to avoid transmitting this movement into the truss. Also, as the deck of the vessel is deformed to cause pivoting of the footing and relative sliding movement between the movable footings and the deck, the slight movement imparted to the relatively loose bolts in the aft footings is accommodated by the provision of the longitudinal slots through which the bolts extend. Since the forward footings for the truss are rigidly an-
chorded to the deck, the deck does not slide with respect to them. However, the forward footings are free to pivot to accommodate any change in angle of the deck with respect to the forward legs. Thus, bending moments imposed on the hull of the floating vessel by wave action are not transmitted to the truss or derrick, thereby permitting the use of lighter construction and reducing the possibility of premature fatigue due to repeated stresses.

I claim:

1. Apparatus for supporting a load on a body of water comprising a deformable floating vessel, a unitary load-bearing structure comprising a pair of upwardly extending load-bearing legs mounted with their lower ends supported by the vessel at spaced locations, an elongated upper chord rigidly connected at longitudinally spaced locations to respective upper portions of the legs, an elongated lower chord rigidly connected at longitudinally spaced locations to the legs below the upper chord to resist any tendency for the lower portions of the legs to move toward and away from each other, means on the vessel providing a lubricated surface for the structure, the lower end of one of the legs being disposed on the lubricated surface and being free to slide with respect to the vessel, and means holding the lower end of the other leg against sliding with respect to the vessel.

2. Apparatus for supporting a load on a body of water comprising a deformable floating vessel, a unitary load-bearing structure comprising a pair of upwardly extending load-bearing legs mounted with their lower ends supported by the vessel at spaced locations, an elongated upper chord rigidly connected at longitudinally spaced locations to respective upper portions of the legs, an elongated lower chord rigidly connected at longitudinally spaced locations to the legs below the upper chord to resist any tendency for the lower portions of the legs to move toward and away from each other, a slidable footing for one of the structure legs adapted to slide with respect to the vessel, and pivot means holding the lower end of the other structure leg against sliding with respect to the vessel.

3. Apparatus for supporting a load on a body of water comprising a deformable floating vessel, a unitary load-bearing structure, a pair of upwardly extending load-bearing legs mounted with their lower ends supported by the vessel at spaced locations, an elongated upper chord rigidly connected at longitudinally spaced locations to respective upper portions of the legs, an elongated lower chord rigidly connected at longitudinally spaced locations to the legs below the upper chord to resist any tendency for the lower portions of the legs to move toward and away from each other, a movable footing for one of the structure legs adapted to move with respect to the vessel, pivot means connecting one of the legs to the movable footing, a fixed footing for the other structure leg immobile with respect to the vessel, and pivot means connecting the other leg to the fixed footing.

4. Deformation isolation apparatus for supporting a load on a body of water comprising a deformable floating vessel, a substantially rigid unitary load-bearing structure comprising a first pair of upwardly extending legs mounted with their lower ends supported by the vessel at spaced locations, a first elongated load-bearing upper chord rigidly attached at longitudinally spaced locations to respective upper portions of the first pair of legs, a first elongated lower chord rigidly connected at longitudinally spaced locations to the first pair of legs below the first upper chord to resist any tendency of the legs to move toward or away from each other and to form a second rigid arch structure component disposed beside the first, and cross bracing connecting the arched components together, one pair of adjacent leg ends of the structure components being free to slide with respect to the vessel, and means holding the other pair of adjacent leg ends against sliding with respect to the vessel.

5. Deformation isolation apparatus for supporting a load on a body of water comprising a deformable floating vessel, a substantially rigid unitary load-bearing structure comprising a first pair of upwardly extending legs mounted with their lower ends supported by the vessel at spaced locations, a first elongated load-bearing upper chord rigidly attached at longitudinally spaced locations to respective upper portions of the first pair of legs, a first elongated lower chord rigidly connected at longitudinally spaced locations to the first pair of legs below the first upper chord to resist any tendency of the legs to move toward or away from each other and to form a second rigid arch structure component, a second pair of upwardly extending legs mounted with their lower ends supported by the vessel at spaced locations, a second elongated load-bearing upper chord rigidly attached at longitudinally spaced locations to respective upper portions of the second pair of legs, a second elongated lower chord rigidly connected at longitudinally spaced locations to the second pair of legs below the second upper chord to resist any tendency of the legs to move toward or away from each other and to form a second rigid arch structure component disposed beside the first, and cross bracing connecting the arched components together, one pair of adjacent leg ends of the structure components being free to slide with respect to the vessel, and means holding the other pair of adjacent leg ends against sliding with respect to the vessel.

6. Deformation isolation apparatus for supporting a load on a body of water comprising a deformable floating vessel, a substantially rigid unitary load-bearing structure comprising a first pair of upwardly extending legs mounted with their lower ends supported by the vessel at spaced locations, a first elongated load-bearing upper chord rigidly connected at longitudinally spaced locations to respective upper portions of the legs, an elongated lower chord separate from the upper chord rigidly connected at longitudinally spaced locations to the legs below the upper chord to resist any tendency of the lower portions of the legs to move toward and away from each other, a movable footing for one of the structure legs adapted to move with respect to the vessel, pivot means connecting one of the legs to the movable footing, a fixed footing for the other structure leg immobile with respect to the vessel, and pivot means holding the lower end of the other leg against sliding with respect to the vessel.

7. Deformation isolation apparatus for supporting a load on a deformable base floating on a body of water comprising a pair of upwardly extending legs mounted with their lower ends supported by the base at spaced locations, a load-bearing upper cord rigidly connected at longitudinally spaced locations to respective upper portions of the legs, a lower cord separate from the upper cord rigidly connected at longitudinally spaced locations to the legs below the upper cord to resist racking of the legs relative to each other, the lower end of one of the legs being pivotally mounted and free to slide with respect to the base, and pivot means holding the lower end of the other leg against sliding with respect to the base.

8. Base deformation isolation apparatus for supporting a load on a deformable base floating on a body of water comprising a substantially rigid unitary load-bearing structure including a forward pair of upwardly extending legs supported by the base at spaced locations, an
aft pair of upwardly extending legs supported by the base at corresponding spaced locations, first elongated load-bearing upper cord members extending fore and aft connected rigidly to the upper ends of corresponding forward and aft legs, second elongated lower cord members separate from the first cord members rigidly connected to corresponding forward and aft legs below the cord members to resist racking of the fore and aft pairs of legs relative to each other and relative to the upper cord members, and transverse cross-bracing between the forward pair of legs and between the aft pair of legs, whereby a load platform is supportable on the load-bearing cord members above the deformable base; pivot means securing one of the pair of legs of the structure to the base, slidable footing means for the other pair of structure legs mounted on the vessel, means pivoted to the other pair of legs for cooperation with the slidable footing means, and means for limiting the slidable co-operation between the slidable footing means and the pivoted means on the other pair of legs.

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